On the Butterfly X-Ray Reflectometer

Markus Weygand

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Chapter 1

Butterfly overview

Welcome to the manual for the Butterfly X-ray reflectometer[1] in the Supramolecular Structures Lab — Lösche group — in the physics department at the Carnegie Mellon University. You will find both annotations to other existing manuals[2] and some detailed guidelines to the operation and maintenace of the spectrometer. The reflectometer was custom designed for the then Lösche group at the University of Leipzig by Jens Linderholm the founder of JJ X-ray a commercial offspring of RISØ the national laboratory of Denmark

The spectrometer is controled by the ECB-module in the electronics rack, which is equipped with its own microprocessing unit, motor controllers, timers & counters for the detectors and an basic video interface for the control displays. The user can either interact with the ECB control unit by operating the manual box or with the *TASCOM* control software package [3] on the Linux control work station via the GPIB interface. The latter option is usually the choice in standart user operation. The GPIB interface of the butterfly reflectometer is the ethernet version from National Instruments and hooked up to the control computer to a dedicated network-card.

1.1 Starting up

Before you are beeing allowed to operate the X-ray reflectometer you must have been gone through the online radiation safety instructions[3] beeing personally instructed on how to control the machine and having been approved by the radition safety officer. Alignment of the butterfly X-ray reflectometer must be performed only by persons aware of and how to properly protect themselves and others against radiation hazards. You are required to sign into the X-ray safety safety booklet [4] for the butterfly-reflectometer whenever you fire up the X-ray generator for a new experimental session and also write down the operation time. In the following section we assume that the cooling circuit is up and running, the detector gaz for the PSD is flowing, the devices

[1] leased from the University of Leipzig and transferred overseas to Pittsburgh, Carnegie Mellon University
[2] like the TASCOM command language or the Siemens Kristalloflex 760 X-ray generator manuals
[3] http://www.cmu.edu/ehs/radiological/training.html#X-raySafetyTraining

in the electronic rack like the ECB unit, the motor-drivers, the high voltage for the PSD, the detector electronics, the histogramming memory, the GPIB interface and the control computer are all powered up and running and you are logged into the *tascom* account.

To **start** the control program TASCOM you have to type `tascom` in the command-line of an open terminal. The program starts up and if everything is right you should view activity of the LED's of the GPIB ethernet interface indicating that TASCOM is trying to connect with the ECB module and the histogramming memory unit. After

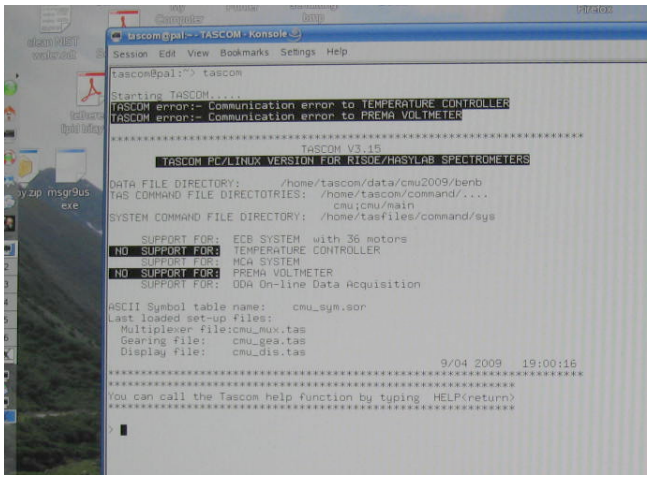

tascom@pal:~ - TASCOM - Konsole
Session Edit View Bookmarks Settings Help
tascom@pal:~> tascom
Starting TASCOM.....
TASCOM error:- Communication error to TEMPERATURE CONTROLLER
TASCOM error:- Communication error to PREMA VOLTMETER
TASCOM V3.15
TASCOM PC/LINUX VERSION FOR RISDE/HASYLAB SPECTROMETERS
DATA FILE DIRECTORY: /home/tascom/data/cmu2009/benb
TAS COMMAND FILE DIRECTOTRIES: /home/tascom/command/....
cmu:cmu/main
SYSTEM COMMAND FILE DIRECTORY: /home/tasfiles/command/sys
SUPPORT FOR: ECB SYSTEM with 36 motors
NO SUPPORT FOR: TEMPERATURE CONTROLLER
SUPPORT FOR: MCA SYSTEM
NO SUPPORT FOR: PREMA VOLTMETER
SUPPORT FOR: ODA On-line Data Acquisition
ASCII Symbol table name: cmu_sym.sor
Last loaded set-up files:
Multiplexer file:cmu_mux.tas
Gearing file: cmu_gea.tas
Display file: cmu_dis.tas
9/04 2009 19:00:16
You can call the Tascom help function by typing HELP<return>
msg9us.exe

Figure 1.1: TASCOM screen after start up.

start up it will display it's version number, the current data file and the command file directories plus a list of supported sub systems. It should claim support for the ECB and MCA sub system as those are essential for operating the spectrometer. Don't worry about missing support messages for the temperature controller and the PREMA voltmeter, these are devices being present at a particular synchrotron beamline in the HASYLAB, DESY (Hamburg) and reveal the history of the control software as an adapted[4] version of the one that controls — or used to control — the horizontal liquid surface diffractometer at BW1. It is worth mentioning that TASCOM provides the command `owl`, that allows the user to easily communicate[5] to external programs which could virtually control anything and communicate back to TASCOM without the need of a specific internal control software add-on or modification. The ODA on-line Data Acquisition supports an external plotting software package, which comes particularly handy for monitoring the current histogramming memory read-out of the PSD detector signal. Then it will print the symbol table, multiplexer file, gearing and display file

[4] After the transfer overseas from Leipzig to Pittsburgh the author of this manual upgraded the control software TASCOM to the most recent version. Some adaptions for CMU are listed in a dedicated section in this manual.

[5] originally implemented by the author of this manual

names and locations, which are so important to the system that they deserve beeing mentioned [3]. Finally it will print the TASCOM command-line prompt:

```
>_
```

You can type in TASCOM command sequences or execute macros which are inside the command directory. The local command directory of the `tascom` account holds the macros to operate the butterfly spectrometer inside the `~/command/cmu/` folder.

1.2 TASCOM Round Trip

The control software of the butterfly reflectometer is the C-version of the program TASCOM[6] that evolved from the original Fortran version developed at the danish national laboratory RISØ in its glorious days. In the following a big picture view is outlined in the hope to enable the user to grasp quickly the more detailed information from the TASCOM user and extension manuals [2, 3] and even from its source code if needed.

The TASCOM program operations are centered internally around the values or states of the so called symbol table that holds the user variable names, build in command names, timer and counter names, stepper motor names, their parameters settings and their current position values. The source code and binary of TASCOM is located in the `cmu` folder in the *home* directory of the `tascomp` account on the Linux work station. Under normal user operation TASCOM updates its values in the

```
/home/tascomp/cmu/tas/symfil/symfil.bin
```

in an — unfortunately — binary representation. An ASCII representation of the symbol table exists but it is beeing used only in the rare case of a symbol table initialization where TASCOM reads the ASCII symbol table and then creates a new binary symbol table file. After such a procedure most likely information like current motor positions, modified gear parameters, soft limits, user defined variables and so on are lost rendering the spectrometer in an ill defined state needing some work to be done to get all symbol table values restored and return the spectrometer operational — at least from the software side point of view. The ASCII source file being used in the CMU incarnation of the butterfly reflectometer is located at:

```
/home/tasfiles/symfil/cmu_sym.sor
```

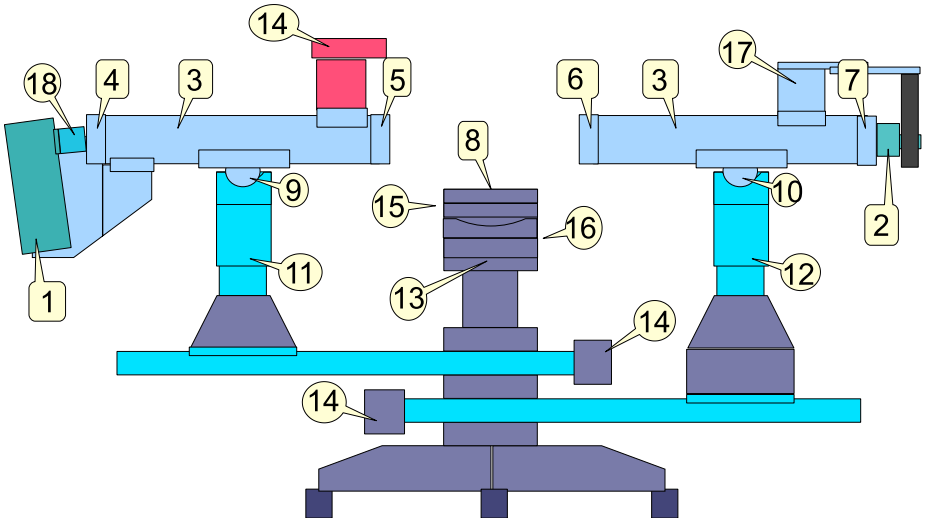
on the `tasfiles` account. For the sake of completness the motor parameters, multiplexer and display files for the CMU butterfly installation are located in:

```
/home/tasfiles/command/cmu_gea.tas
/home/tasfiles/command/cmu_mux.tas
/home/tasfiles/command/cmu_dis.tas
```

Note the obvious adaptations of those files names to the particular installation and mind to adapt your actions accordingly in case you want to follow procedures described in

[6] TASCOM is the shortcut for **T***riple* **A***xis* **S***pectrometer* **Com***munication program*

the TASCOM user manual [3]. TASCOM features its own macro language which is somewhat fortranish in its syntax but does not require a strict format nor capital letters. Macros can be defined and placed in the command directory in files with an extension `.tas` in the file name. On typing a command in the command line TASCOM searches first its symbol table and if that fails the command directory and if that failes TASCOM issues an error message. In case you assign a value to a variable that is not yet defined in the symbol table TASCOM adds a new variable to the binary symbol-table. Particularly it created a new symbol in the symbol table if you accidently misspell a variable name. In order to avoid a symbol table pollution you should delete accidently user created symbols from the symbol table using the command `dels`, e.g. `dels tempp` [3].



1	X-ray tube	7	Slit 3	13	Translation sample height `tzs`
2	PSD	8	sample table	14	Counter weight
3	Flight tube	9	Rotation arm source side `rox`	15	Translation x-y sample `txs, tys`
4	Attenuator	10	Rotation arm detector side `rod`	16	Goniometer sample `gxs, gys`
5	Slit 1	11	Height translation source arm `tzx`	17	Detektor holder
6	Slit 2	12	Height translation detector arm `tzd`	18	Göbel mirror

Figure 1.2: Butterfly scheme

1.2.1 Important motors

This is the list of the most important motor of the butterfly reflectometer. All the names have been defined such in the `cmu_sym.sor`.

`tzs` translation z-direction sample-table
`tzx` translation z-direction tower X-ray source-side
`tzd` translation z-direction tower detector-side

`rox`	rotation X-ray source-side arm
`rod`	rotation detector-side arm
`txs`	translation x-direction sample-table
`tys`	translation y-direction sample-table
`gxs`	goniometer x-axis sample-table
`gys`	goniometer y-axis sample-table

Most of the motors are addressed in normal user operation indirectly by commands through the execution of specific macros. Motors names not mentioned in this list are the ones for the slits and absorbers. Those macros or cammands will be mentioned later and the inspection of their source is encouraged.

1.2.2 Important system variables

In the original symbol table source variables– intended for a specific use – are defined such as `segn` for the segment number suffix or `fina` for the prefix in the data file names. Some system variables are state variables e.g. `prsc`, which sets the scaler mode to either counting till a certain number — to be defined in another system variable `pres` — of counts or time, others are read-only[7] variables like timers and scalers, e.g. `I`. A list of some of the more important system variables include:

`I`	holds intensity value read by `coun` command
`TIM`	holds value of timer started by a `coun` command
`RATE`	set to 1 enables rate meter; set to 0 disables rate meter; i.e. continous counting
`PRSC`	set scaler mode. If set to 0 scaler is in time mode; otherwise i=1,2,3 selects number of counts from detector i. The butterfly uses currently only one detector — the Braun PSD — which is i=2.
`PRES`	holds the preset value for the scaler
`SEGN`	holds current segment number
`DFIT`	holds comment string for the current data file
`CEMA`	center of mass calculated by built in statistic function in the `plot` command
`MIDP`	holds the mid point of internal statistics evaluation. Very useful for scans.

You can print the value of a variable, a motor position or perform a calculation using the print command `?` f.x. the number of counts measured during the last `coun` command:

```
?I
```

[7] each symbol table entry has a scope field, a number that is used by TASCOM to discriminate the type of a command sting after parsing it: variable, command, read-only variable, etc.

1.2.3 Scans

Scanning the motor position against detector counts is a frequent task during operation the butterfly. The basic scan macro `sma` for scanning the absolute position against detector counts is provided in the tasfiles command directory. Its usage is

```
sma motor, start pos, end pos, steps, pres
```

The following line is frequently used for the sample height scan before a reflectivity measurement:

```
?tzs sma tzs,tzs-0.3,tzs+.3,31,1
```

The first command `?tzs` prints the current motor position, the second command `sma tzs...` scans the motor `tzs` in 31 steps ± 0.3 against its current position `tzs`. Note that the value of the sample height is plotted before the height scan. This is a good pratice in case you decide to move the motor position back to the original value. All scans and macros can be stopped by hitting `ctr-c`. Mind that the sequence `ctr-d` suspends on Unix/Linux a program to the background. If you happen to hit accidently `ctr-d` instead of `ctr-c` TASCOM still keeps running in the background and you can get the TASCOM console back to forground by typing `fg` into the terminal window. After a succesfull scan you can assign the sample height to the calculated midpoint value:

```
tzs=midp
```

The command directory of the butterfly reflectometer holds many more sophisticated scan macros for operating the spectrometer.

1.2.4 Macros

The typical structure of a macro is explained in detail in the TASCOM user manual. Nevertheless a particularity of the use of semicolons in TASCOM is beeing outlined here. Whenever TASCOM parses a macro it parses the source till a the occurance of a semicolon and then executes. This can have interesting consequences f.x. if you decide to seperate operations in a macro by a semicolons and say the first piece till the semicolon parses without an error message, then TASCOM will execute that part and parse the next piece of code till the next semicolon. If a subsequent piece of code has an error an error message will be issued and causes TASCOM to abort the execution of the macro. It is thus adviced to check the macro for errors before executing it for a scan, especially if that one is intended to take a long time.

1.3 Operation

In the following the normal operation of the butterfly reflectometer is outlined. We assume the butterfly reflectomter is aligned, all sub-systems are up and running and a liquid interface in the Langmuir-Blodgett trough of proper height is the sample. A liquid surface has the advantage that it is horizontal by gravity, whereas a solid sample

might need first an alignment to be horizontally to the beam using the goniometer motors, which is an obvious step preceding the following procedure.

1.3.1 Absorber

The detector should not get much more than 6000 counts/second. Thus the direct beam must be attenuated in order to protect the detector (PSD), which is done by the attenuator. The attenuator is modified slit where the motors moves instead of jaws aluminium foils of different thickness into the direct beam. The four jars carry 2, 4, 8 or 16 layers of an aluminium foil, thus totally 16 absorber settings are possible. Make sure that you select an appropriate absorber settings once you put the reflectometer into a direct beam or low angle setting. `attb` *number* sets attenuator factor by selecting a state between 0 and 15. State 15 has all absorber slides in beam and the highest attenuation, state 0 all attenuation foils out of the beam. `atten` *val* set attenuator value to an attenuation factor of at least *val*. For info from online help type `help 'atten'`. The macro `atten` defines internally attenuation factors for each of the alumium absorbers, which go into the calculation od the attenuation factor `atte`.

```
atten_s0 = 2.4      ! --> M21 --> ab0
atten_s1 = 4.8      ! --> M14 --> ab1
atten_s2 = 27.2     ! --> M29 --> ab2
atten_s3 = 777.8    ! --> M13 --> ab3
```

These values should be checked. The macro `patten` prints the current absorber state.

1.3.2 Typical scan

A sample is prepared in the LB trough or a waver is mounted on a flat support in the center of the sample table. The reflectomter is put in save starting state with the command `go_home`, which cares for slit settings of slit1, attenuator settings and sets the reflectomter to $0.75 \times \alpha_{critical}$ so that the sample surface is expected to serve as a mirror. The critical angle is stored in the user variable `ac` and it is up to the user to update its value to e.g. water or silicon oxide surfaces `ac_h2o` or `ac_si`.

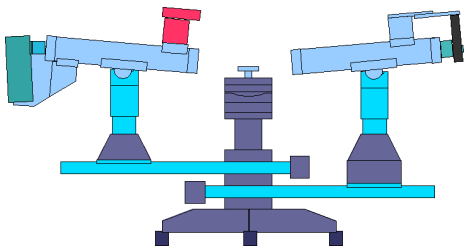


Figure 1.3: The flight tubes point to the sample placed in the center of the sample table. A sample height scan is performed typically in the reflected position at butterfly setting of the angle at $0.85 \times \alpha_{critical}$.

Open the shutter 1 on the front of the Siemens X-ray generator [1]. The reflectomter is in a position where the sample serves (or should serve) as a mirror, and just the right height of the sample has to be determined. This is usually done in a two step process. In the first step select the motor `tzs` with the manual box and use the joy stick to move the motor and watch the rate meter or the counts/second on the monitor from the ECB module. Once you have found the maximum count rate you can start a scan.

```
> attb 9
> ! or whatever the necessary attenuation is
> bfly 0.85*ac
> ?tzs sma tzs,tzs-0.3,tzs+.3,31,1
```

If the scan is done and the result looks like a gaussian with a fwhm of ≈ 0.25 you can set the sample height to the maximum.

```
> tzs=midp
```

In case you want to check alignment or make a scan of a waver you need to perform an angular offset scan, which will be explained in more detail in the alignment section.

```
> soff -.3,.3,31,1
```

If a proper maximum is found, set the new angular offset value

```
> offbfly midp
```

in order to set the reflectometer to the maximum position. If the offset is off, repeat the sample height and offset scans until you find iteratively a stable configuartion.

The command `bfly` *alpha* sets the incident and exit angle to the *alpha*. The command `sbfly` *abeg*, *aned*, *npoi*, *pres*, *i*0 is the primitive scan macro for reflectivity scans. Its usage for complete scans be looked up in macros like `gold.tas` or `mucus.tas` in the command file directory.

Slits

The slits are motorized and slit settings can be modified during operation. An example provide the scan macros `mucus` which calls macros like `slitset1b` to set the horizontal opening of slit 1. The settings of slit2 and slit3 remain unchanged — as set in the initial instrument alignment. The horizontal slit width/opening of slit 1 is particularly crucial during an reflectivity experiment. For shallow angles of incidence the horizontal width of slit 1 must be set small to reduce footprint size of the incoming beam, whereas for larger angles of incidence the footprint of the incoming X-ray beam has a reduced and it is desirable to make the horizontal width of slit 1 as wide as possible to get as many photons hitting the sample. Slit 1 and have horizonatl and vertical openings whereas slit 3 has only a horizontal opening.

Slit commands

Slit commandos operate on the *current* slit. The current slit is selected by the commands `sel_hsl` [123] for a horizontal slit or `sel_vsl` [12] for vertical apertures. The `slit` help page provides additional information of the slit settings macros.

`sel_hsl` [123]	select horizontal slit # to current slit
`sel_vsl` [12]	select vertical slit # to current slit
`slpo`	list all slit settings
`lcsl`	list current slit setting
`mcslp` *p*	move current slit to pos
`mcslw` *w*	move current slit to width
`scslp` *pmin*, *pmax*, *npoi*, *pres*	scan relative to current position
`scslw` *wbeg*, *wend*, *npoi*, *pres*	scan slit width of current slit
`rcslp` *p*, *w*	rename current slit state to position and width

References

[1] Siemens. *KRISTALLOFLEX 760 X-ray Generator*, 1993–1995.

[2] Per Skaarup. *TASCOM Extension Manual*. Risø, 1997.

[3] Per Skaarup. *TASCOM User Manual*. Risø, 2003.

[4] Markus Weygand and John Zoll. *Siemens Kristalloflex 760 Butterfly Reflectomter (logbook)*. CMU, 2008.

Chapter 2

Alignment

2.1 Coarse alignment

The coarse alignment is the optical adjustment of the detector and source arm. This step is ususally necessary only after a complete dismantling of the reflectomter – rather seldom.

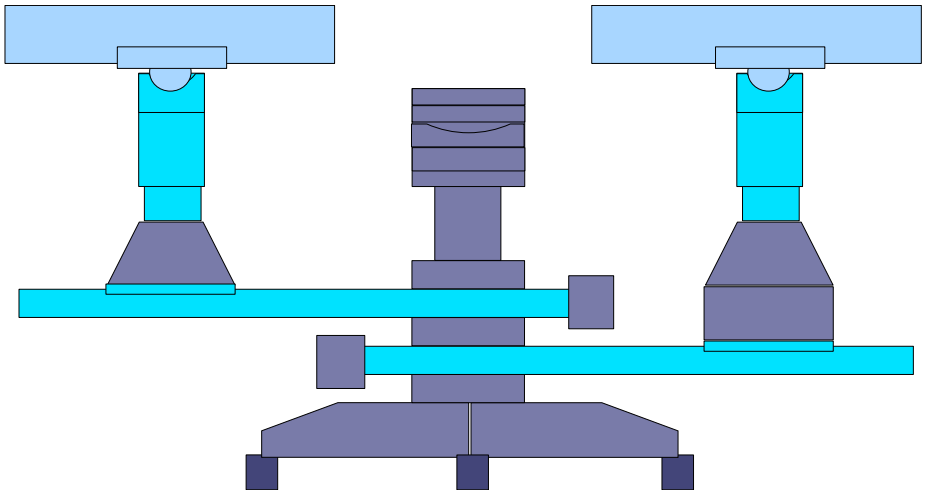


Figure 2.1: Butterfly, no parts mounted on the flight tubes.

The first step is to place the arms of the naked (figure 2.1) butterfly horizontal as good as possible using the rotational degrees of freedom, i.e. motors `rox, rod`. Make the motor adjustments from the manual box. Use first the scale of the goniomters, there might be still some usefull marks from previous work. Then take the telescope

and use appropriate marks[1] at the front and back end of the arm you want to level. After leveling the arms place them on the same height using the translational degree of freedom, i.e. `tzx, tzd` and the telescope. When this is done the to flight tubes have to be aligned uniaxially. This is done by adjusting the lower arm `2tl` in the plane of incidence, so that both arms are aligned uniaxially. Use a horizontally levelled[2] laser to perform this task.

Obey laser saftey rules!

When you found an optical horizontal, remember (husk) this setting with the command:

```
> husk_hor
```

Later you can move the motors back to that horizontal reference position with the command `gohor`. Help on alignment is availible in the TASCOM help system — just type `help 'refl'`.

2.2 Adjustment of the Göbel mirror

The adjustment of the Göbel mirror falls into three stages.

1. search for the characteristic line (fx. after sealed vacuum tube exchange)
2. orient the beam along the flight tube axis
3. optimize the focused beam shape

Warning:

All work for Göbel mirror alignment must be done with X-ray tube powered on and shutter open.

Follow radiation safety rules [4]

Use the portable counter before any new operation.

You must wear your radiation batches, especially the finger ring.

Use lead shielding against back scattered radiation.

The safest place is to behind the tube.

Stand **only** on side with mounting plate for the mirror and tube case.

Always close the shutter before you change a slit.

[1] if you don't find any good marks or scratches or whatever, go and take a ruler and scale and make your own ones!

[2] A laser can be levelled with the help of a tranparent hoase. Fill a 5m hoase with water and observe the menisca of both ends.

2.2.1 Adjustment of the Göbel mirror from scratch

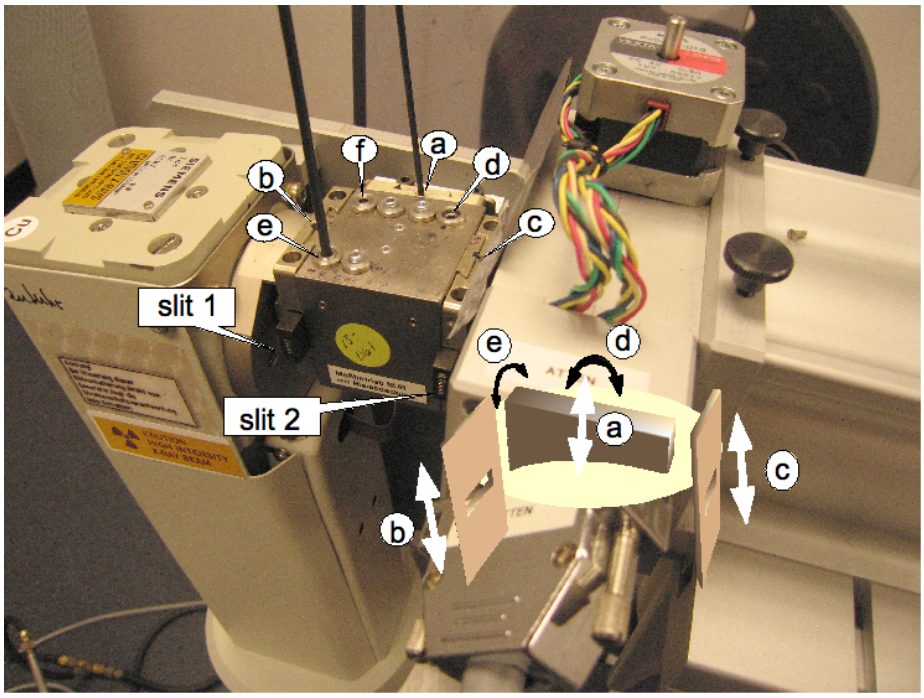


Figure 2.2: The Göbel mirror and its skrews. Never touch the unlabeled ones.

slit 1	illumination slit insert
slit 2	exit aperture insert

a	moves the of Göbel mirror case against beam (focal height)
b	moves illumination slit (*slit 1*) against Göbel mirror
c	moves exit slit (*slit 2*) against Göbel mirror
d	tilts Göbel mirror against beam
e	tilts Göbel mirror against slits
f	combination of movement d and e of the Göbel mirror (better not move at all)

The adjustment of the Göbel mirror is done visually with the help of flourescence screens and the X-ray eye, and CCD camera. The observation is done after the first flight tube in the sample table areal. Remove all attenuator slides out of the beam (type either `atten 1` or `attb 0`). Insert the 6 mm slit in the *slit 1* holder, remove the exit slit (*slit 2* (figure 2.2) and cover the opening of *slit 2* at the side with a partially inserted slit or a piece of led. Unmount slit 1 — from the butterfly scheme (figure 1.2) not the Göbel mirror — if it is not yet unmounted and pose it on the floor or on the flat area of the `2tu` arm.

Operate the X-ray tube under lowest power (20 kV/5 mA) and open the shutter [2]. **You must check for scattered radiation in the surroundings of the tube with the portable counter and apply lead sheets and lead plastic shield as needed. Never stand at the side where the slits are being inserted in the Göbel mirror case, when the shutter is open (the front side in figure 2.2).**

The mirror is essentially a plate that must be lowered and slightly tilted against the incoming X-ray beam. The correct tilt is required to get the desired monochromatic X-ray beam.

First level the skrews **d**, **e** and **f** so that they align flatly with the case. You must **always** move the skrews first in downwards direction and then upwards to the desired position in order to compensate for the mechanic backlash. You should be able to see a simple bright band on the flourescent sreen above the center of the flight tube (figure 2.4 i). Make sure that this band is not confined by the illumination slit and use the skrew **b** for adjustment. Turn skrew **a** and move the band until an upper confinement appears. Now tilt the Göbel mirror by turning skrew **d** up to the point where the upper confinement remains unchanged (figure 2.4 ii). The mirror is positioned parallel to the beam.

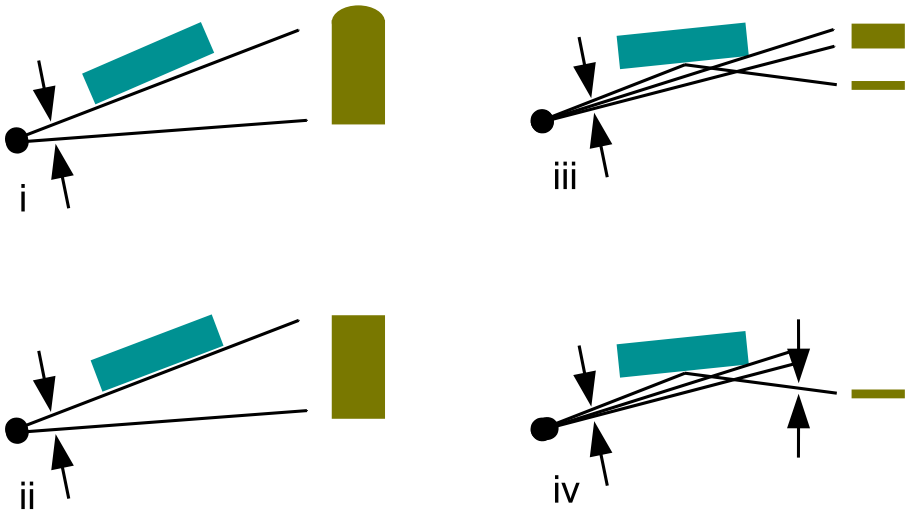


Figure 2.3: The major steps in the Göbel mirror alignment. i) with illumination slit 6 mm a broad bright band is visible on the flourescent screen or the X-ray eye. ii) tilt Göbel mirror parallel to the X-ray beam. iii) insert the 1 mm illumination slit and select the Cu_{K_α} line. iv) insert the 0.6 mm exit slit.

The next step is to tilt the mirror forward, by turning skrew **d** inwards into the casing. At some point the K_β line will appear and then the K_α line[3] The tilt (skrews **d, e**) must optimized so that the K_α line gets intense.

[3]The K_α line is made of two lines K_{α_1}, K_{α_2} that are close together.

Now insert the 1 mm illumination slit and place the 6 mm in the exit aperture holder. Vary the height of the illumination slit (skrew **b**) until the bright line reappears and a small remaining of the bright band is visible (figure 2.4 iii). If only the band is visible then the illumination slit is too low.

2.2.2 Shift and tilt the collimated beam

The collimated beam must be oriented uniaxially to the flight tubes. A small deviation however can be dealt with easily in the subsequent alignment.

Changes in the tilt of the collimated beam must be done by altering the initial height of the Göbel mirror casing (skrew **a**). Then proceed with the same procedure as described in the last section.

When the colliminated beam is oriented well enough uniaxially respectively to the flight tube, insert the 0.6 mm slit in the exit aperture (slit 2 in figure 2.2) of the Göbel mirror case and adjust its height using skrew **c** until the beam is visible again (figure 2.4 iv).

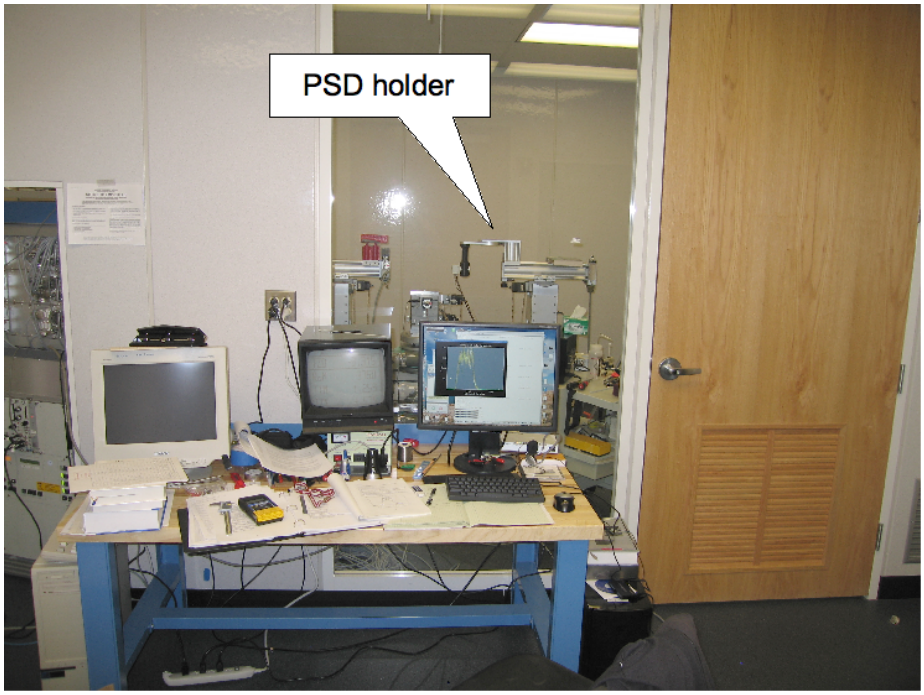


Figure 2.4: The detector holder can be used for holding the X-ray eye with an cylidricatal adapter or the PSD right after the first flight tube during Göbel mirror optimazation and subsequent alignment.

For the final optimazation of the collimated beam power the X-ray generator up the operating power of 45 kV/35 mA and wait least 90 min to reach termal stabilty.

Observe the collimated beam with the X-ray eye and maximize the intensity of line by adjusting *slightly* the height of the illumination slit, the Göbel mirror height and tilt using the skrews **b**, **a** and **d**.

Optimize the beam by adjusting *slightly* the exit slit height and the tilt of the mirror against the slits using the skrews **d** and **c**.

If you don't trust your eyes and want quantitative information perform the last step with the PSD and observe MCA read out with the **online** graphical visualazation program under an update rate of 1 second [1, 3]. You **must** attenuate the direct beam in order to prevent damage of the detector. Start with the highest attenuation factor and lower it until the count rate is in the range of 6000 counts/second.

2.3 Alignment of the Butterfly

The butterfly geometry is an essentially symmetric setup designed for specular reflectometry on liquid or other planar surfaces oriented in the horizontal plane.

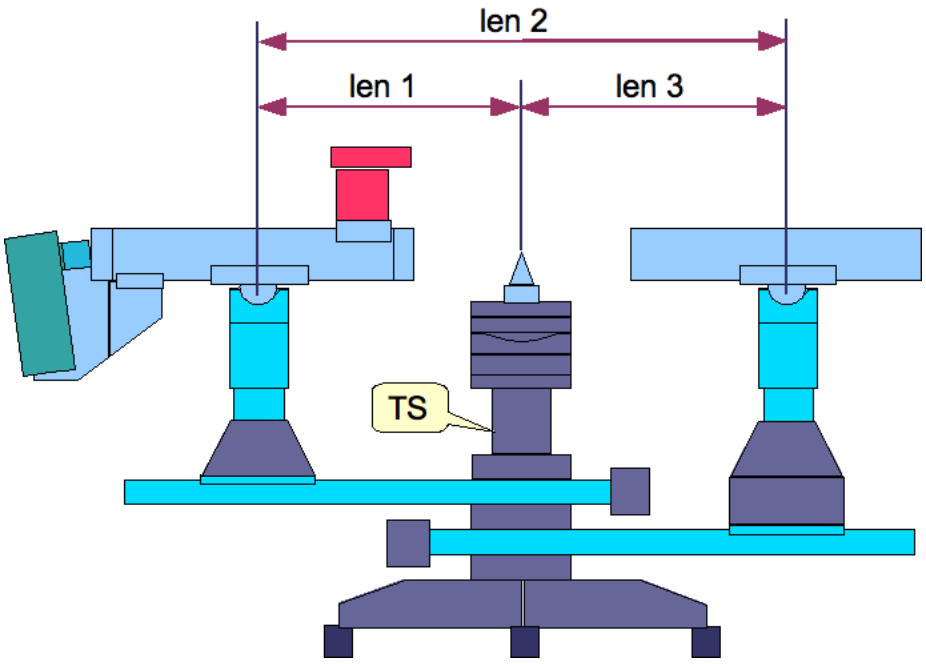


Figure 2.5: The lengths *len*1 and *len*3 must be known for reflectivity operation mode. The xy movements of the sample table must be adjusted with the help of a telescope so that a pin placed in the recess is perfectly centered. The centered sample table carries later a precision machined cross being used in th alignment.

The sample is mounted on the sample elevator table and rests there during the measurement. Both the source side and the detector side arm possess a translational

and a rotational degrees of freedom (and even more degrees of freedom if we consider the possible slit movements). Due to the pattern of the arm movements in an experiment people called this type of reflectometer a *butterfly*. The initial optical alignmet of the flight tubes into a horizontal plane serves as the starting point for the fine alignment of the butterfly (pp. 11). The fine alignment breaks up into the following steps (these steps serve as a *guidline* and don't replace (totally) own thinking; scan ranges needed may be different and so on; it is also **strongly** recommended to look into the macros.):

- Mount the aluminium plate with the round recess in the center on sample table.

  You might have to unmount another aluminium plate from the sample table tower — most likely the ground plate for the Langmuir Blodgett trough.

- Center a pin on the sample table (take the small goniometer with the sharp pin which fits precisely in the round recess of the square aluminium support plate). You the telescope as a visual aid and observe the tip under a 90° rotation of the sample table (to do this unhinge the gear box of motor `TS`. Perform these rotations manually and be gentle with the cables around.)

- Determine *len*1 and *len*2 with steel rulers as well as you can.

- Mount the detector holder on the second flight tube so that it can carry the PSD in the sample table area. Search the direct beam moving the height of the second flight tube (`tzd`) using the manual box.

- Mount slit 1 and align slit 1. Set the attenuator and start with the hightest at-

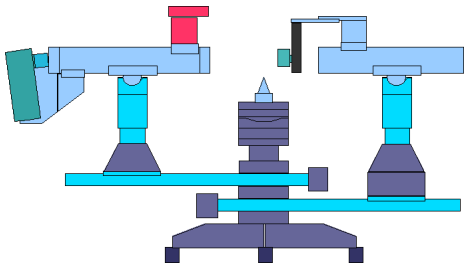


Figure 2.6: Align slit1 with the PSD mounted in the sample tabe area.

  tenuation factor (`attb 15` or `atten 200000`). The unit of the slit motors movements are set to multiples of 100 μm. Most likely the the slit settings from the previous alignment are somewhat useful, especially the widths and position. Select the horizontal aperture of slit1 and open it 500 μm wide.

```
> sel_hsl 1
> mcslw 5
```

  The next step is to perform a height scan of the slit aperture. The macro `scslp` performs a scan relative to the current position and returns to the position before the scan, e.g.

```
> scslp -30,30,31,1
```

Mind that these scans should be used with some care so that you don't exceed the mechanical limits in the planned jaw movements. Reduce the scan range from ± 30 (as in the example above) to say ± 10 for the fine scan. Move the slit position to the center of the scan.

```
> mcslp midp
```

After the slit height is found, check for the slit width and scan the slit width using the current slit width scan:

```
> scslw 70,-10,81,1
```

Like in the position scan this macro returns to the slit state before the scan.

You can assign a slit state a position value p or/and the slit width w. The command macro uses internally the `remo` command [3]. You are responsible for a meaningful result.

```
> rcslp p,w
```

And finally you can print the current slit settings/values.

```
> lcsl
```

For the sake of completness the macro `slpo` prints info about all slits.

- Mount the X-ray eye instead of the PSD in the detector holder using the custom machined cylindrical aluminium adapter observe the direct beam with the X-ray eye.
- Place the cross in the sample table center and move the sample height table `tzs` so that the cross just obscures the direct beam (use the *Manual box, slow movements*). Note its position value into the TASOM variable `tzsb`.
- **Track the length** *len*1**.** The command `bfly` *alpha* moves the butterfly into the expected position for specular reflectivity under the angle of incidence *alpha*. The proper operation depends on correct values for the lengths, *len*1 and *len*3 in TASCOM. The read the current values in TASCOM type

  ```
  > ?len1,len3
  ```

  Assign your newly measured length values to the TASCOM variables *len*1 and *len*2 and make TASCOM remember the current position of the X-ray side of the butterfly as its reference horizontal position for reflectometry calculations.

  ```
  > husk_xwing 0
  ```

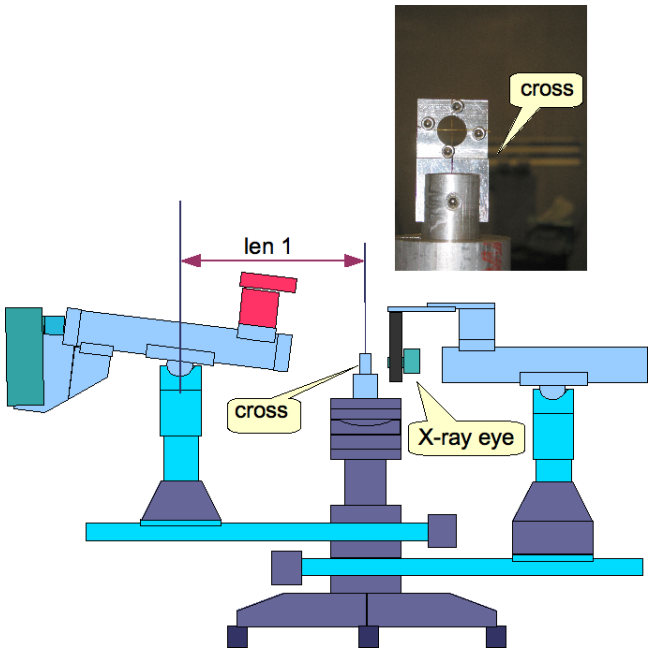


Figure 2.7: Track length *len*1 with the cross and X-ray eye.

If *len*1 was perfectly correct, the direct beam would always hit the center of the cross and being obscured from the X-ray eye (check `tzs` with manual box) if the incoming arm is being set to the calculated position for any chosen incoming angle *alpha*. The macro which moves only the motors for the first arm into the calculated butterfly position under an angle *alpha* is called `xwing` and used like

```
> xwing 2
```

in order to position the first arm to the theoretical position for the angle of incidence of 2°. The tracking of the error is done by observing the deviation of the center of the cross from the beam under various angles, like 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5 degrees. Obviously the height of the X-ray eye must be adjusted for larger angles of incidence. The theoretical relative height displacement of the flight tube respective to the horizontal position for an angle of incidence α is $txhe = len_1 * \tan\alpha$. Note down the observed deviation $\Delta z = tzs - tzsb$, where tzs is the position of the sample height where the cross precisely obscures the X-ray beam. The macro `diffs` prints this difference for convenience (that is the reason you stored the sample height for the horizontal case). Make a file with the values α for the angles of incidence and the observed deviations Δz. You can use gnuplot to fit the linear regression curve (type `help fit` inside gnuplot). Fix the value of *len*1 if a systematic deviation could be traced.

- Unmount detector and align the detector arm to the plane of incidence with the help of a flourescent screen and adjust the `2tl`, either using the manual box or manually with unhinged motor gears.
- Mount *slit*2 and *slit*3, open jaws wide
- Mount detector holder towards the end of the second flight tube.
- Align *slit*2. The procedure is similar to alignment of *slit*1. Start with selecting the *slit*2.

  ```
  > sel_hsl 1
  > mcslw 10
  ```

  The scanning commands are now exactly the same. Mind that because of the slight divergence of the collimated beam the slit must be set wider in order to catch the direct beam. Scan the position and the scan the width.
- Align *slit*3. The same procedure like for *slit*1 and *slit*2 except that this slit has only horizontal jaws.

  ```
  > sel_hsl 3
  > mcslw 15
  ```

  Close the vertical jaws *slit*1 slightly in order to allow to discriminate background and signal channels on the PSD. The commands needed could be something like

  ```
  > sel_vsl 1
  > mcslw 12
  ```

  A sample slit scan is performed, like:

  ```
  > scslp -25,25,31,1
  ```

  Remember that you can move the (here vertical) position with the slit moving macro `mcslp` *p* if you need that.
- In order to **track** *len*3 follow the direct beam with the PSD mounted at the back of the second flight tube under various angles of incidence, starting by remembering the optical horizontal reference position

  ```
  > direct 0
  > ! rememeber the reference TZD position
  > sdhe = tzd
  ```

  to set the instrumet to 0° tilt. Set the butterfly to various tilts of the dirct beam like 0, 0.5, 1, 1.5, 2, 2.5, 3...

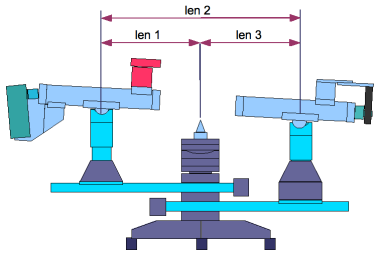


Figure 2.8: The butterly set to the direct beam.

```
> direct 0.5
```

Scan the height of the second flight tube, note the found *mid p* and its difference to the theoretical value `sdhe`, which was calculated by the `direct` macro. A convenience macro exists in the command directory that prints that difference.

```
> diffd
```

Write down the angles and the differences on paper and/or to a file and calculate the linear regression f.x. with gnuplot. In case you spot a systematic deviation correct the value of *len*3 accordingly and check if the correction was done properly.

- Mount Langmuir Blodget Trough and prepare a bare water surface. Place the glass block in the range of the foot print and fill the trough with water, so that the are cobered by a 300μm water layer above.
- Find the angular offset of the beam regarding the water surface. The optical horizontal is a straight line by construction, which may or may not be perfectly horizontally oriented.

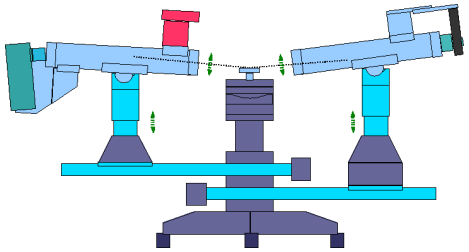


Figure 2.9: Offset scan.

Remember that horizontal state for TASCOM with the command `husk_bfly 0`. Then make a sample height scan — the arms still horizontal — and position

`tzs` where the sample cuts half of the beam. Then set the butterfly into specular reflective position and scan the sample height again and set `tzs` to the *midp*.

```
> bfly 0.85*ac
> ?tzs sma tzs,tzs-0.3,tzs+.3,31,1
> tzs=midp
```

Then scan the angular offset and place the offset to the *midp*.

```
> soff -.3,.3,31,1
> offbfly midp
```

You must probably repeat the sample height and offset scans and get iteratively to the desired state. Once you have found a proper alignment remember this state for TASCOM as the reference state.

```
> husk_bfly 0.85*ac
```

- Make a reflectivity scan of the bare water surface and check for the critical angle. You can start as simple as

```
> slitset1b
> attenb 8
> sbfly .1*ac,2.5*ac,22,3000,1
```

Adapt old scan macros if necessary, especially for slit settings and channel number for signal and background of the PSD.

References

[1] MBraun. *Mbraun 50mm PSD, Manual – now HECUS*.

[2] Siemens. *KRISTALLOFLEX 760 X-ray Generator*, 1993–1995.

[3] Per Skaarup. *TASCOM User Manual*. Risø, 2003.

[4] Markus Weygand and John Zoll. *Siemens Kristalloflex 760 Butterfly Reflectomter (logbook)*. CMU, 2008.

Chapter 3

Macros

3.1 TASCOM

`go_home`	set the butterfly in a safe starting position.
`bfly` $alfa$	move butterfly to specular reflectivity position of angle of incidence $alfa$.
`sbfly` $abeg, aend, npoi, pres, i0$	basic reflectivity scan
`soff` $offa, offb, npoi, pres$	offset angle scan for current specular reflectivity position. Typically $0.85 \times \alpha_{critical}$.
`offbfly` off	apply an angular offset to current butterfly/alfa state.
`husk_bfly` $atru$	remembers (*danish* at huske) the current butterfly state as the state for specular reflectivity of an angle of incidence $atru$. This is achieved by determing offset values, which are added to the theoretical positions for motor movements (elevator towers translations and rotations of the flight tubes). The command freezes the current state as the reference for the angle $atru$.
`direct` $alfa$	set the butterfly to direct beam of angle $alfa$
`xwing` $alfa$	set only the X-ray source arm to the butterfly angle $alfa$
`dwing` $alfa$	set only the detector arm to the butterfly angle $alfa$
`bfly_pri` $alfa$	like `bfly` but only prints hypothetical movements. No movements made.
`direct_pri` $alfa$	like `direct` but only prints hypothetical movements. No movements made.
`lisa`	list current butterfly state
`sel_hsl` num	select horizontal slit num, $num \in 1,2,3$ as the current one.
`sel_vsl` num	select vertical slit num, $num \in 1,2$ as the current one.
`lcsl`	list curren slit positions.
`slpo`	list all slit positions.
`mcslp` p	move current slit position to p.
`mcslp` w	move current slit width to w.
`rcsk` $pos, width$	remo current slit setting to pos and $width$.
`sabs` $abn, abst$	moves absorber blade abn in if $abst = 1$, or out if $abst = 0$
`lpsd`	read contiously the MCA histogramming memory. This macro is useful for observing the current PSD counts.

3.2 Gnuplot

Macros can be loaded in *gnuplot* by the command `load 'macro'`. A useful macro is `frsn` which has Fresnel functions for the reciprocal and angular space defined.

```
set log y
qc_h2o=0.0217
qc_si=0.0314
qc=qc_h2o
ff(x)= (x*x-qc*qc)**.5
f(x)= x < qc ? 1 : ((x-ff(x))/(x+ff(x)))**2
fs(x,s)= f(x)*exp(-x*x*s*s)
a2q(x)=4*pi/1.542*sin(x*pi/180.)
fa(x)=f(a2q(x))
fsa(x,s)=fs(a2q(x),s)
```

The macro `reload` repeats the last plot commando, which comes handy during scans. Printer output can be placed conviently into a macro such as `print`. Adapt it to the latest printer names and/or the desired Postscript (or other terminal options) options.

```
set ter post color
#set output "|lpr -Pbutterfly"
#set ter post color
set output "|lpr -Phpcolor"
#set ter post mono
#set output "|lpr -Posage"
repl
set output "plot.ps"
repl
set ter X11
repl
```

Rich documentation for *gnuplot* is available inside the program through the built in help system and the *gnuplot* home page *http://www.gnuplot.info/*.

3.3 Perl

The macro `tasrd` extracts information from TASCOM data and array files. Extract for example the data columns for `Q1, REFL, SREFL` from a reflectivity data file `xxxx007.ref` with

```
tasrd -s "Q1 REFL SREFL" xxxx007.dat
```

Values stored in the paramter line are being extracted with the additional option switch `-p`, e.g. `tasrd -p -s "ss se bs be" xxxx007.ref`. Arrays are accessed by indicating square brackets, or by an index range

```
tasrd -s "Q1 DD[]" xxxx007.dat
tasrd -s "Q1 DD[23:90]" xxxx007.dat
```

The sum over an array range is taken with prefix `s` inside the square bracket after the array name, e.g

```
tasrd -s "Q1 DD[s23:90] DD[s100:200]" xxxx007.dat
```

Values stored in the paramter line are extracted just with the additional option switch, e.g. `tasrd -p -s "ss se bs be" xxxx007.ref`.

A mixed access to file parameter and header parameter is possible as well (in that order) with the option `-P`, e.g.

```
tasrd -s "Q1 REFL SREFL" -P -s "ss se" xxxx007.ref
```

Type `tasrd -h` for the build in help.

3.4 R

R is a software environment for statistics with rich graphical capabilities and features a functional programming language. In some ways it is similar to `Matlab` or `IDL`. An introduction is available in the documentation at the home page of the R-Project *http://www.r-project.org/* or closer to you at *http://lib.stat.cmu.edu/R/CRAN/*. A reference card is located at *http://cran.r-project.org/doc/contrib/Short-refcard.pdf*.

Type `R` in a free terminal to start R. The command `source("parratt.R")` reads the file `parratt.R` into R. This command is used for running batch files or loading macros.

3.4.1 Reflectivity Calculation

The Parratt iteration is implemented in the `parratt` function.

```
function(x,d,del,sig=2.7,bet=0) {

  theta <- 0.5*abs(x);
  nmax  <- length(d);
  nx    <- length(x);

  rn <- an <- f <- array(0i, c(nmax,nx));

  if (length(sig) == 1) {
    sig <- rep(sig,nmax);
  }

  if (length(bet) == 1) {
    bet <- rep(bet,nmax);
  }
```

```
  for(i in 1:nmax) {
    f[i,]=sqrt(theta^2-2*del[i]-2i*bet[i]);
  }

  an[1:(nmax-1),] <- (f[1:(nmax-1),]-f[2:nmax,])/
                     (f[1:(nmax-1),]+f[2:nmax,]);

  # modified reflection coefficient
  if (length(sig) == length(d)){
    msig <- array(sig[2:nmax]^2, c(nmax-1,nx));
    an[1:nmax-1,] <- an[1:(nmax-1),]*
      exp(-2*msig*f[2:nmax,]*f[1:(nmax-1),]);
  }

  for (n in nmax:2) {
    rn[n-1, ] <- exp((2.*d[n-1]*-1i*f[n-1, ]))*
      (rn[n, ]+an[n-1, ])/(rn[n, ]*an[n-1, ]+1.);
  }

  Re(rn[1, ]*Conj(rn[1, ]));
  #r <- Re(rn[1, ]*Conj(rn[1, ]));
  #r;

}
```

As an example of its usage a Fresnel curve for neutrons is being calculated. The function `qc2nrho` calculates the neutron scattering length density from a given critical angle.

```
qz <- seq(0.001,0.25,by=0.005)
qc=0.021764
qc2nrho(qc) -> rsub
slux <-  2.817938e-05 # X-rays
slun <-1 # Neutrons
slu = slun # the example is for neutrons
parratt(qz, c(0,0), 2*slu*pi*c(0,rsub),sig=2.7) -> refl
plot(qz, refl, log="y")
```

3.4.2 Read Data Files into R

The following example illustrates how `tasrd` macro is being used to read some reflectivity data file `ndata.ref` into R.

```
rdng7 <- function(file="pgmD2O_0507.ref",
                                path=/home/tascom/data/) {
        # read corrected Neutron data files
```

```
        parameter='"Qz R dR"'
        cur_file=paste(path,file,sep="")
        command=paste('tasrd -R -s',parameter,cur_file);
        print(command);
        data = read.table(pipe(command), header=TRUE);
        return (data)
}

mypath="/home/tascom/myneudata"
myfile="ndata.ref"

data=rdng7(file=myfile,path=mypath)

# print data structure information

str(data)
```

Note particularly the lines with the `paste` command that glues several strings together to one command string. The convenience function `num2fnum(`*segn*`)` adds leading zeros to numbersand formates them in the same way TASCOM does the *segn* suffix in the `.dat` file names. This command (the perl macro `tasrd...`) is then exectuted in the `read.table(pipe(), )` command.

3.4.3 Tweak Reflectivity Data

A typical reflectivity scan on the butterfly is made of several scans with different slit and attenuator settings. Overlaps of subsequent scan serve to determine the overlap factor which comprises slit and attenuator settings and possibly sample artefacts.

```
husk_ac=ac
ac=ac_h2o

slitset05
attenb 7
sbfly 0.1*ac, 1.5*ac, 31, 3000, 1

attenb 3
sbfly 1.3*ac, 3*ac, 25, 3000, 1

attenb 0
sbfly 2.7*ac, 4*ac, 15, 3000, 1

slitset1b
sbfly 3.7*ac, 5.5*ac, 15, 3000, 1

slitset3
```

```
sbfly 4.5*ac, 15*ac, 10, 3000, 1

slitset5c
sbfly 13.5*ac, 28*ac, 14  , 3000, 1
sbfly 29.0*ac, 5.1, 3, 3000, 1
!
date
attenb 8 slitset1b
ac=husk_ac
```

The whole reflectivity scan comprises seven pieces and only the last two ones have the identical slit and attenuator settings. The `slitsetXX` macros contain setting for the slit 1, the footprint slit.

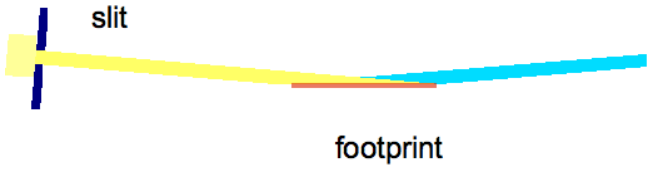


Figure 3.1: The slit width on the left defines the width of the incoming beam under angle α. The wider the beam is the larger the footprint f gets; $f = w \times \sin\alpha$. The divergence of the beam is dominated by the Göbel mirror divergence ($\approx 0.05°$).

```
slitset05.tas:
! small angle

sel_hsl 1 mcslw 0.5   sel_vsl 1 mcslw 12
sel_hsl 2 mcslw 7
sel_hsl 3 mcslw 8

ss=115 se=225 bs=10 be=110
iv=1

?ss,se,bs,be

slitset1b.tas:
! small angle
sel_hsl 1 mcslw 1   sel_vsl 1 mcslw 12
sel_hsl 2 mcslw 7
sel_hsl 3 mcslw 8
!ss=120 se=220 bs=10 be=110
ss=115 se=225 bs=10 be=110
```

```
iv=1
?ss,se,bs,be

slitset3.tas:
! medium angle
sel_hsl 1 mcslw 3   sel_vsl 1 mcslw 12
sel_hsl 2 mcslw 7
sel_hsl 3 mcslw 8
! slitset3/slitset1b   2.98864
iv=1
ss=115 se=225 bs=10 be=110

slitset5.tas:
! slit combination
sel_hsl 1 mcslw  5   sel_vsl 1 mcslw 12
sel_hsl 2 mcslw 12
sel_hsl 3 mcslw 14
iv=23.30606
! iv=39.89384
bs=20   be=110   ss=120   se=220
?ss,se,bs,be
```

Use the function `rdbfly` to read reflectivity data of this type of scan. Assuming the current data path is `/home/tascom/data/cmu2009/mark/`, the prefix `fina` is called `mark` and the scan starts with the `segn` 123, the data are being read with following command.

```
cur_path="/home/tascom/data/cmu2009/mark/"
dat=rdbfly(segn=123,fin_segn=-1,fina="mark",path=cur_path)
```

Assuming the overlap factors have been determined somewhere else (f.x. in *gnuplot*) and stored in R in the array `mm` the reflectivity data are plotted is plotted with the command

```
mm  =c(3000.000, 30.000, 12.000, 2.500, 2.000, 1.475)
plrty (dat, facs=calc_facs(mm) )
# obviously the overlap factors can be adjusted
# in a straight forward manner by changing values in mm
```

The next step is to discriminate the signal channel form the background ones. At low momentum transfers q_z or at small angles of incidence α for that matter the signal to noise ratio is so high that we may neglegt the background. Since the vertical aperture is not changed during the reflectivity measurement we can use the small angle region for the signal/background discrimantion.

The `plrty` command displays per default the 2D image (figure 3.2) of the reflectivity scan, where on the y-axis the PSD channels are being displayed (up to the applied overlap factors) and on the x-axis the momentum transfer q_z. R provides the function

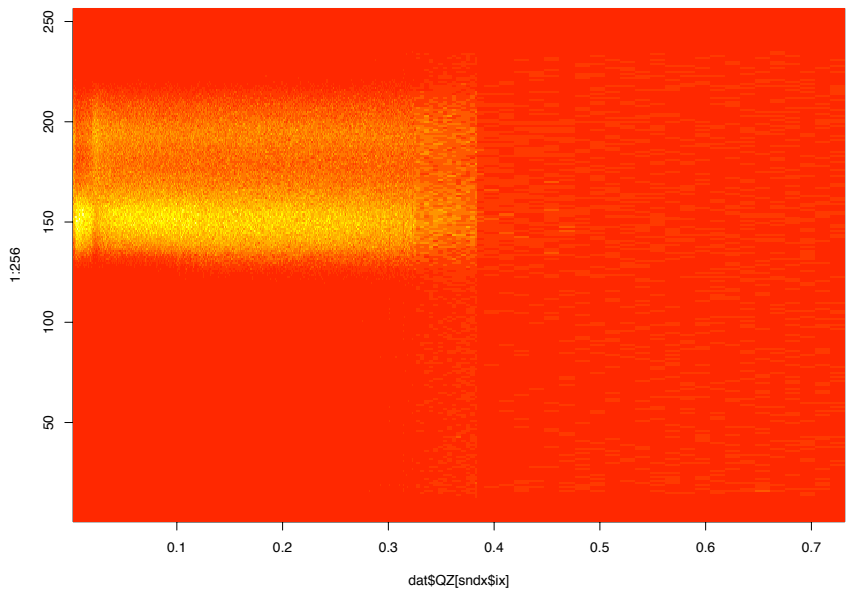


Figure 3.2: The 2D image of a reflectivity scan of a water surface in the Langmuir Trough displayed using the command `plrty`. With the build in R command `locator()` it is easy to determine the channels numbers in the image with the mouse.

`locator()` [1] that gives you coordinates of the image back you have clicked at. Click with the left mouse button the on the borders of the signal range and do use many spots in the low angle region and determine the signal range `ss:se` (signal start : signal end). Determine the backgr ound range `bs:be`. Don't use blindly a too low channel number for `bs` in order to avoid the detector edges. Update the `slitsetXX` macros to the new ranges.

The reflectivity data is being recalculated based on the novel ranges with the `twrty` function.

```
twrty(dat, facs=calc_facs(mm),
      bounds=list(ss=126,se=216,bs=15,be=125)) -> ref
```

Finally the data structure `ref` can be inspected with the R command `str`. An easy way to store the corrected reflectivity data is using the R command `write.table`.

```
str(ref) # shows data structure
write.table(ref,"H2O.ref",row.names=FALSE,quote=FALSE)
```

[1] type `help(locator)` in R for build in help

Chapter 4

The Langmuir Trough

4.1 Hardware

The Langmuir Blodgett Trough consists of an aluminium enclosure with a window capton foil for the X-rays and carries a teflon trough inside.

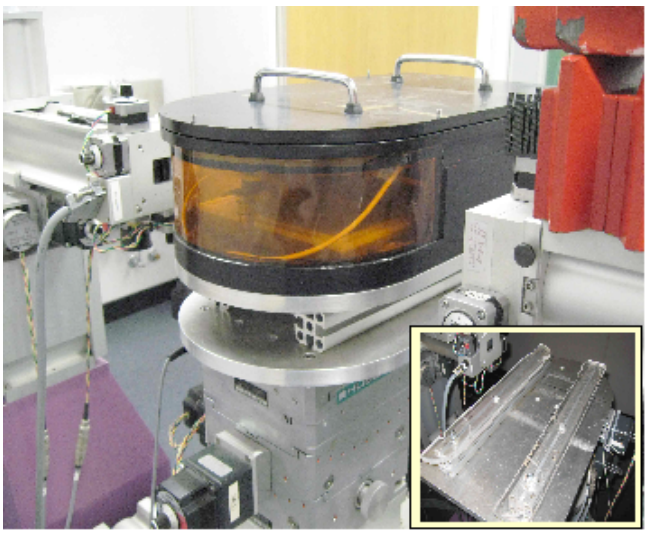


Figure 4.1: Film balance mounted on sample table. The small insert schows the aluminium support rails and the plexi glass pieces that support the trough. The trough is fixed by four screws from below.

The temperature in the trough can be controlled using water flowing through copper tubings beneath the trough. The trough mechanics comprises an electrical motor with a gear box which drives a teflon barrier via a belt. The author of this manual has precision

machined a barrier made of Delrin.

Sensors can be accessed from outside the casing via air tight plugs such as the barrier position read out (a potentiometer), a Pt100 temperature sensor, oxygen sensor and the Wilhelmi sensor for surface tension measurements.

4.2 Tiger

The hardware is controlled by a Film Balance Controller designed by Bernd Kohlstrunk at the University of Leipzig. The controller can command the film balance stand alone. For data read out however some external computer must communicate with that controller via the serial interface. The film balance controller comes with its own documentation [1, 2].

4.2.1 Isowiso

XF A program written by the author of this manual — Markus Weygand — can issue commands to and read data from the film balance controller. It is made available in the local `~/bin` directory of the `tascom` account. The communication is done with serial protocol over an USB to serial interface converter. In order to read the current status (i.e. position, lateral surface pressure and area) from the film balance controller type

```
isowiso -a
```

or

```
isowiso -l 1
```

for a continous output every second.

Examples of *isowiso* usage are:

isowiso -v -a	read current status i.e. position, lateral surface pressure and area.
isowiso -v -l arg	read current status every *arg* second.
isowiso -v -b	read current barrier position
isowiso -v -l arg	read current status every *arg* second.
isowiso -T	switch sets output prope for TASCOM command the `owl`.
isowiso -b arg	set barrier position soll
isowiso -p arg	set lateral surface pressure soll
isowiso -s arg	set speed index (0..9)
isowiso -v -g 1 -f xxx.ref	store curent status to file xxx.ref every second
isowiso -c "a comment"	add this option to the above command to store a comment in the created data file.

Read the current status from inside TASCOM with the command

```
owl 'isowiso -T -a',pos,pi_lat,area
```

which stores the result of to the TASCOM user variables `pos`, `pi_lat` and `area`.

Type `isowiso -h` for the build in help information.

References

[1] Bernd Kohlstrunk. *Manual: Balance Controller Version 2.0*. University of Leipzig.

[2] Bernd Kohlstrunk. *Menu scheme Balance Controller*. University of Leipzig.

Chapter 5

Technical Notes

Finally a collection of facts and pieces of useful information on the equipment are given.

5.1 JJXray

This company did design and construct the spectrometer. They are located in Danmark. Their web page is *http://www.jjxray.dk/conus.html*.

JJ X-ray A/S
Diplomvej 377, Scion-DTU
DK-2800 Kgs. Lyngby
Danmark

Telephone: +45 4776 3000
Fax: +45 4776 3001

VAT: DK-2952 3215

5.2 Siemes Kristalloflex 760 X-Ray Generator

The Kristalloflex is the high voltage source for the sealed X-ray vacuum tube. This device is usually part of a Siemens[1] X-ray solution. JJ-Xray chose only the generator part for the butterfly design. Siemens no longer owns the X-ray department and sold it to Bruker. Contact Bruker AXS for Inc for service needs.

[1] It is helpful to tell that to a Bruker AXS service person.

USA and Canada
BRUKER AXS Inc.
5465 East Cheryl Parkway
Madison, WI 53711-5373
USA
Tel. +1 (800) 234-XRAY (For customers calling from US or Canada)

5.2.1 Safety Circuit

The safety circuits [3] of the X-ray generator include the door interlook, which is a mgnetic switch at the door to the X-ray experimental enclosure. If this circuit is open the shutter at the X-ray tube holder closes or does not open. One way interrupt the interlock is to pull off the bana plug at the bottom of the X-ray tube stand [6]. Outside the enclosure an X-ray warning light is switch on (via a relais), if the X-ray generator engages high voltage to the X-ray tube. If the shutter is open a warning light **inside** the experimantal enclosure is being engaged. Failure to engage this warning light will result in a breakdown of the interlock. If the light bulb is dead ity must be replaced.

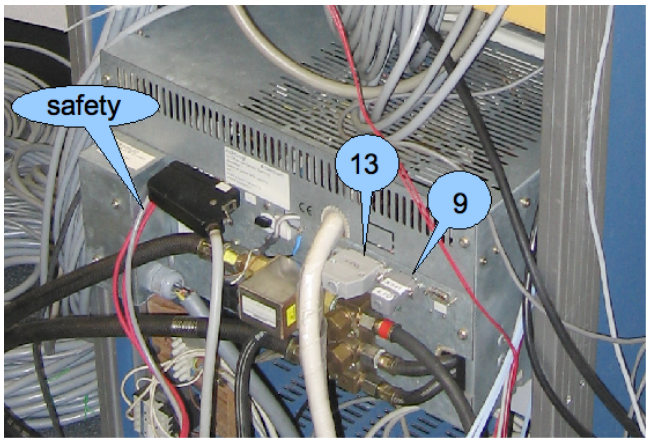


Figure 5.1: Backside of the X-ray generator. Customized 9 pin and 13 pin plugs bridge safety circuit settings [3]. The safety cables serve for the interlock, the X-ray warning lamp and the shutter warning light bulb.

5.3 Haskris Chiller

the Haskris chiller is a refurbished model bought from JS Technical Services. Their address is

Marguerite Stauver
JS Technical Services

(940) 382-2934 Voice
(940) 898-0150 Fax
6159 Moss Rose Lane
Aubrey, TX 76227
www.jstechnicalservices.com
e-mail: jstech1@airmail.net

However since it is a Haskris device, you better deal with Haskris for spare parts, such as the brass pump.

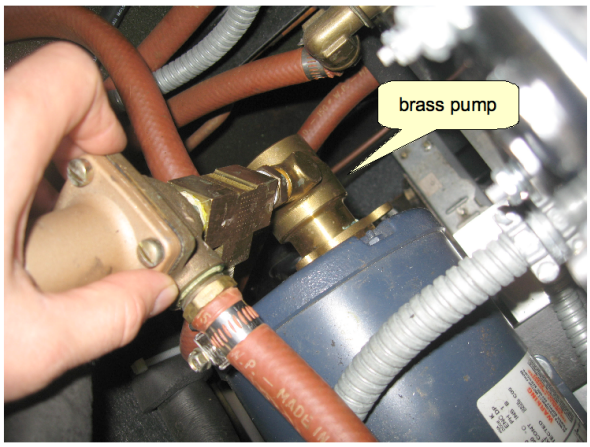


Figure 5.2: Haskris chiller. The brass pump is a consumable.

Hi Marcus,
PN 1370, Pump Model 102L100F11XX, $131.91 ea., excluding freight.
Pump includes new coupling.
Doug Wagner
Haskris Co.
tel 847-956-6420, x243

fax 847-956-6595
email: doug@haskris.com

If you change the X-ray tube you must switch off the chiller and unhook the hoases from the tube stand. Remember which tube was pumping the water in and which one out. The direction matters.

5.4 Sealed X-Ray Vacuum Tube

The X-ray source is a fine line copper K_α sealed vacuum source. The operation power settings are 45kV, 35mA. Increase first the high voltage to target value and then current.

5.5 Braun PSD

Figure 5.3: The detector gaz bottle. The fitting is customized in order to connect to the MBraun gaz hoases.

The detector is described in the producers manual [2]. The fitting for the detector gaz has been customized (figure 5.3). Select the PSD as the current detecor from TASCOM with the following counter setting [5]

```
prsc=2
```

You must set `rate` to 0 during a scan and to 1 to be able to read the current counte rate on the b/w display of the ECB module. The TASOM user manual [5] describes the MCA commands for reading, clearing the histogramming memory and the timer functions that are availible to TASCOM through the ECB module.

MBraun no more sells position sensitive detectors and this business is taken over by the austrian X-ray systems GmbH HECUS.

Reininghausstrasse 13a
A-8020 Graz, AUSTRIA
Tel. +43 (0)316 / 48 11 18
Fax: +43(0)316/48 11 18 – –20

e-mail: officehecus.at
Office Hours:
Mon – Thu 08:00 – 16:00h
Fri 08:00 – 12:00h CET

5.6 TASCOM

The TASCOM [4, 5] version used in CMU is v3.15 and is identical to the TASCOM version used at the liquid surface diffractomter with some modifications. The ECB module, ancillary electronics and the motor drivers hardware is described in the documentation from JJX-ray [1].

5.6.1 Adaptations of TASCOM for the CMU installation

- Moved home directory from `/usr/users/tascom` to `/home/tascom`, similarly moved the accounts `/home/tascomp` and `/home/tasfiles`. Some header files of the TASCOM source have been changed.
- The `mca.c` file is being patched to work with the local MCA.
- Gpib driver updated to stable National Instrument version hooked up to a dedicated network card.
- Makefile modified for updated gpib driver.
- The symbol table is newly defined for the butterfly at CMU.

5.6.2 Online

The *online* program is an online visualization for current scan that belongs to the TASCOM [5] distribution. A particular important feature is its ability to display the current mca histogramming memory content (through shared memory communication with TASCOM).

Start the program *pgplot* for monitoring the current histogramming memory (MCA) content from a free terminal window.

```
cd /home/tascom/tasplot_Dec03
./plot 3 0 0 3 0
```

You can monitor the MCA readings continously with the TASCOM command sequence

```
> whle 1..eq.1 cmca wait 1 rmca next
```

This sequence is for convenience stored in the macro `lpsd` in the command directory.

References

[1] Jens Linderholm. *Løsche Leipzig, S2641a*. JJ X-Ray, 1996.

[2] MBraun. *Mbraun 50mm PSD, Manual – now HECUS*.

[3] Siemens. *KRISTALLOFLEX 760 X-ray Generator*, 1993–1995.

[4] Per Skaarup. *TASCOM Extension Manual*. Risø, 1997.

[5] Per Skaarup. *TASCOM User Manual*. Risø, 2003.

[6] Markus Weygand and John Zoll. *Siemens Kristalloflex 760 Butterfly Reflectomter (logbook)*. CMU, 2008.